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A Study of Issues:

Concerning a Proposed Broadband Allocation within the 900 MHz Land Mobile Radio Band and Its Potential Impact on the Florida Power & Light Network

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I. SUMMARY.

As the Commission considers the PDV/EWA petition (updated by the Petitioners' "FURTHER COMMENTS" on May 1, 2018) to reconfigure the 900 MHz band to provide a broadband allocation, it should consider whether such a re-configuration is possible while:

- Protecting the rights of incumbent licensees to:
  - continue their operations including expansions with comparable service quality and reliability
  - operate without harmful interference that damages service quality that would encumber their mission to maintain critical infrastructure services.
- Ensuring that band rules provide equitable protection and rights for incumbent narrowband operators and Private Enterprise Broadband (PEBB) operators, while also considering existing precedent particularly in the form of existing rules or standards for similar bands.
- Considering what mechanism would be used to award exclusive area broadband licenses, now proposed as over 700 separate areas.

The petition presented by PDV/EWA (Petitioners) raises multiple concerns that cover broad areas of technical and administrative issues that are not addressed by the Petitioners' proposal and suggested rules, as well as issues with specific areas in the Petitioners' suggested rules themselves. A summary of concerns is given below, with detailed comments following.

- No analysis exists to show that the residual bandwidth available for existing narrowband licensees that wish to continue their operations is sufficient. In fact, several issues exemplify the challenges associated with the proposed Land Mobile Radio (LMR) allocation that, as most recently proposed, consists of only 148 channels compared with the current configuration of 399 channels.

  - We will also show that the effective allocation is significantly smaller because channels near the broadband allocations will likely be subject to higher levels of interference.
  - Selecting a channel or even the channel set required for a multi-site LMR system is already challenging. Additional constraints in the form of fewer channels added to the numerous existing constraints make channel selection exponentially more difficult.

- The provisions for license relocation and negotiation are new and heavily favor the Petitioners. These rules should be based on rules from the 700 and 800 MHz bands with adjustments made for best practices, lessons learned since these rules were enacted, and potential differences or unique aspects of the 900 MHz band.
- The proposed rules call for awarding an exclusive broadband licensee in each Metropolitan Statistical Area (MSA) or county at a cost substantially below market value. Award is simply conditioned on showing 240 channels of licenses where the FCC pool of unused licenses is provided for free.
- Interference protection rules and transmitter spectral energy containment rules (emission masks and out of band energy rules), while related, play separate roles in managing spectral sharing. Ultimately, transmitter spectral energy containment rules determine how often harmful interference may occur. Interference protection rules decide whether the interference must be mitigated by the transmitter operator. Both sets of rules must be set appropriately for any proposed band allocation to balance the needs of the incumbent licensees, and new proposed users. These rules also play a vital role in ensuring that the rights of license holders are protected from continuing rounds of interference mitigation.

- Technical rules should also be devised that are relatively consistent. By example, an emission mask requirement that can be shown in typical deployments to cause harmful interference that exceeds the protection rules does not make sense. If this were deployed, then the PEBB and incumbent LMR operators would be in a constant process of interference mitigation.
- The interference protection rules proposed by the Petitioners rely on a mix of existing rules and new rules, but the proposed rules appear to be selected or created to favor the Petitioners' interest rather than balancing incumbent and new user needs to ensure co-existence.
- Many licensees in the 900 MHz band use their channels for critical infrastructure management and service restoration. Existing licensees provide interoperability services and mutual aid channels to public safety departments particularly in rural areas. Some are even acting as the primary dispatch and communication network provider in compliance with 47 CFR §90.179. Public safety agencies and critical infrastructure providers, particularly during service restoration operations, are operating a mission critical communications network and should be afforded the same protections as other mission critical bands like the 700 and 800 MHz LMR bands.

II. THE PROPOSED 2 MHZ NARROWBAND ALLOCATION IS NOT SUFFICIENT FOR CURRENT AND FUTURE NEEDS

The Petitioners seek to deploy a high density cellular network into the 900 MHz spectrum, while leaving less than 1.85 MHz of residual bandwidth for continuing narrowband operations. This narrower allocation challenges frequency re-use and reduces coverage in existing narrowband systems, while also limiting potential growth of these systems.

A. Channel Re-use

Channel re-use in LMR systems is a function of multiple constraints that ensure predictable and reliable coverage in the existing 5+5 MHz band. First, while there are 399 (47 CFR §90.613) 12.5 kHz channels defined in the 900 MHz band only 199 channels are assigned to the Business, Industrial and Land Transportation (B/I/LT) pool (47 CFR §90.617) used by FPL. Of those channels Florida Power and Light (FPL) uses 156 in their system with most channels re-used multiple times. Second, 47 CFR § 90.621 provides rules for limiting the minimum distance between co-channel stations. While the rules include various provisions for larger or smaller spacing, most re-use is constrained to a spacing of 70 miles. Larger spacing is required for stations with antennas at high height relative to the surrounding coverage area and/ or effective radiated power above prescribed thresholds. However, due to Florida's flat topology and limited tower heights these rules are generally not required for frequency coordination of the FPL system with other licensees that share the same service area. That said, detailed analysis of specific co-channel pairs may find that larger spacing is required in some cases due to the specifics of site configurations and the intervening geography between site pairs. In fact, that has proven to be the case in the FPL system. A limited number of co-channel pairs have required larger spacing to provide reliable communication with in the site serving area.

FCC rules allow for "short spacing" of co-channel assignments, but then require sign-offs from all relevant parties. In general, a third party has little interest in receiving additional interference to their operations by accepting short spacing instances. Therefore, short spacing can most effectively be considered for channel re-use within a single system where interference can be carefully analyzed and managed. Then, by exception "short spacing" assignments between communication systems may be considered as required. This approach prefers adoption of efficient channel re-use schemes within communication systems rather than the more complex and burdensome task of coordination of short spacing with other licensees.

Within the constraints of rules for the current 5+5 MHz band, significant work has been required to optimize channel assignments for the FPL LMR system that provides an acceptable level of intra-system co-channel interference while meeting requirements for inter-system co-channel re-use. Over a two-year period, FPL has worked diligently with frequency planners in an iterative process to identify inter-system co-channel short spacing and intra-system co-channel short spacing that causes harmful interference. For inter-system co-channel analysis, the FCC rules are used which most commonly limit re-use to 70-mile spacing. Intra-system analysis uses a sophisticated coverage prediction tool (RAPTR) to evaluate the actual interference for the specific co-channel pairs. The tool considers all relevant transmitter and receiver parameters, models the physical morphology of the terrain between co-channel stations, and accounts for land use losses. Out of this process, channel pairs are identified that will result in harmful interference, and an optimization process is applied that changes base station channel assignments within the FPL system with the initial constraint of existing channel licenses to mitigate co-channel harmful interference. Following this process, channel frequency changes are identified that will further mitigate interference, but require license changes. Frequency coordination identifies new channel assignments that may be applied to reduce harmful interference. This process is then repeated until an acceptable level of performance is achieved.

Following this 2-year process, FPL has settled on an acceptable level of performance for its deployment, with the understanding that small adjustments to the system may be necessary post deployment for unanticipated issues. The following statistics provide some evidence of the difficulty of the optimization process by showing its current optimized state.

- The FPL system has a total of 68 sites. Of those sites, 14 have at least one intra-system channel assignment that has a co-channel re-use that affects audio quality from 1-5% of the time, even considering that the best serving base station is selected.

- The FPL system has 44 re-use instances (frequency pairs) with spacings of less than 70 miles. These are predicted to provide acceptable performance, but 9 are anticipated to have audio quality issues from 1-5% of the time. All 44 re-use instances can be anticipated to have limited system margin; that essentially means that additional constraints on frequency planning could easily move these instances into unacceptable performance. Likewise, additional constraints would likely create more instances with limited system margin or unacceptable performance.
- The FPL system has 5 instances of channel re-use with spacing greater than 70 miles where audio quality issues are expected to exist from 1-5% of the time. The FCC rule constraint is based on a generic model of RF propagation loss that does not consider all the specifics of a re-use instance. Therefore, it can be expected that detailed modeling would identify re-use instances with more the 70-mile spacing that present with interference issues.

Based on these statistics, the 70-mile spacing for co-channel re-use is justified as a "rule of thumb" for initial planning, but detailed analysis is required of specific co-channel instances to understand whether short spacing may be possible or that a larger spacing is required for acceptable performance.

The optimized frequency plan for the FPL system can be used as a model to understand the implications of the proposed petition to allow a broadband allocation in the 900 MHz band. This model applies directly to FPL, but may also be extended to understand the implications to other 900 MHz LMR systems of similar complexity.

As currently proposed, the petition substantially reduces the available channels for LMR communications. Figure 1 illustrates the current and proposed frequency plan for the 900 MHz band. As shown in the current frequency plan, FPL licenses channels in the red segments (B/I/LT) of the spectrum that are interleaved with the orange lettered segments (SMR). The current rules allow for 199 frequency channels in the B/I/LT segments of which FPL has licenses for 156. The petition proposed rules that call for a total of 148 frequency channels that must be shared among all Specialized Mobile Radio (SMR) and B/I/LT license holders operating LMR systems. A search of the current licensing database reveals that there are 2071 licenses in the 5+5 MHz band for LMR in Florida. Of those, 1770 are B/I/LT with the remaining SMR. FPL is the largest holder of B/I/LT licenses with 575. PDV Holdings has 408, Duke Energy 174, Note Acquisitions 153, Industrial Technologies 144, and Cemex Construction Materials 61. The remaining 255 licenses are spread over several owners.

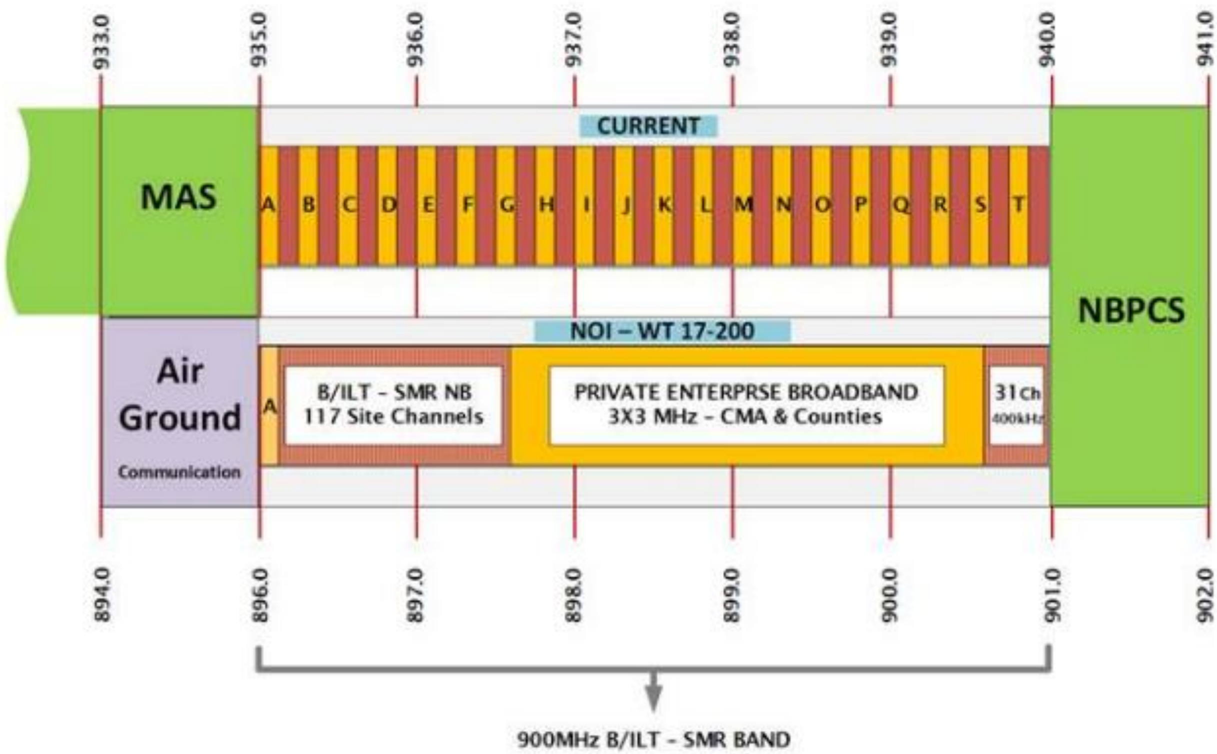

Figure 1, Existing and Proposed 900 MHz Band

As proposed, the petition requires that SMR and B/I/LT licensees that currently have access to a total of 399 channels be limited to 148 channels. It further requires that licensees need to vacate any current licenses that are within the proposed broadband allocation while receiving comparable facilities within the LMR allocation. The current petition does not provide a timeframe or even a commitment for the buildout of a broadband system, but encumbers existing LMR systems from maintaining or changing their existing licenses. The 900 MHz band has evolved over time as licenses were granted. While it is impossible to accurately predict the mix of broadband and LMR licensees after a rules change, we can state that frequency planning that is already difficult will become much harder or even impossible.

B. Lost Coverage

The FPL communication system is designed to support mission critical communication that protects worker safety, but also quickens service restoration that is essential for public safety. A reconfigured band as proposed can be expected to reduce the coverage of an existing LMR communications system through two primary mechanisms: closer spacing of transmitter carriers and interference caused by LTE sites.

1. Interference from LTE sites

Based on the Petitioners' recommended emission mask, the effects of LTE base station out of band energy are relatively easy to predict. The Petitioners have recommended 50 + 10log(P) as the emission mask at the LTE base station transmitter output, where P is the transmitter power in watts. While this requirement appears to be dependent on transmitter power, it is equivalent to -20 dBm. The proposed measurement bandwidth for this band is 100 kHz except for LMR channels within 100 kHz of the PEBB allocation. In this case, 1% of the broadband signal bandwidth or 30 kHz (for a 3 MHz LTE carrier) may be used. Therefore, the

Analysis Parameters

1. I_{Rx}: Noise at the device receiver input
2. I_{OOBE} : -20 dBm is equivalent to 50 + 10log(P)
3. P_{Tx}: eNB 40 W RMS power
4. B_{res}: Analyzer BW 100 kHz for emission mask
5. B_{P25}: Effective P25 BW 5.7 kHz
6. $G_{Tx}(h,r)$: eNB antenna gain
7. G_{Rx} : device receiver gain: -4 dB
8. λ : wavelength 0.32 m (~940 MHz)
9. r : distance from the tower base to the device
10. h : equivalent antenna height
11. kT : thermal noise -174 dBm/ Hz
12. F_{NF} : receiver noise figure 6 dB

Figure 2, Parameters

transmitter can generate up to -20 dBm of noise energy per the measurement bandwidth. Since, the duplexing separation is 39 MHz, no benefit is expected from duplexer output filtering for frequency separations inclusive of the 5 MHz allocation at 900 MHz nor is any provided by the recommended rules. Interference can be analyzed for a typical base station with a typical panel antenna at various tower heights to model some range site scenarios. Figure 2 provides parameters used for the analysis. Figure 3 shows the predicted signal strength incident on the Project 25 (P25) receiver necessary to provide Delivered Audio Quality (DAQ) 3.4 voice quality. In this case, the interference source is considered line of sight and therefore not subject to fading. The desired P25 signal is presumed to be relatively distant and subject to fading. Figure 3 shows the expected P25 receiver sensitivity as a function of distance from the interfering LTE site for LTE base antenna heights of 10, 30, and 100 meters. At close range, the directivity effects of the base antenna are evident in the improvement in receiver sensitivity at very close range. As shown for the 30-meter base antenna height, a relative minimum in received power required exists immediately under the tower. At about 40 meters range, a relative maximum exists due to a side lobe of the base station panel directivity. The maximum is followed by a more extended lower interference zone until the range is great enough for the base station antenna to engage its main beam. The 10-meter and 100-meter scenarios show similar patterns that are expanded or contracted based on the antenna height. The specifics of the interference levels from LTE base stations incident on LMR radios in the proximity of broadband sites will vary with the directivity pattern of the deployed site radiation. Antenna selection, antenna height, and down tilt are all optimizations that can be made to manage harmful broadband interference to LMR radios. However, optimizations to prevent harmful interference will constrain the PEBB operator from adjusting these antenna characteristics to maximize LTE capacity.

Horizontal lines shown on the graph illustrate various significant receiver signal levels:

- In red, the proposed 900 MHz protection level
- In blue, the 800 MHz protection level
- In green, the receiver sensitivity typically used for coverage designs in LMR
- In gold, the noise limited sensitivity of a typical receiver in a faded environment

Proper interpretation of this graph is important. First, the graph illustrates the median signal strength of the desired LMR signal that must be incident at the LMR receiver for it to overcome the nearby LTE base station interference and present audio with a minimum DAQ of 3.4. Three scenarios are presented that

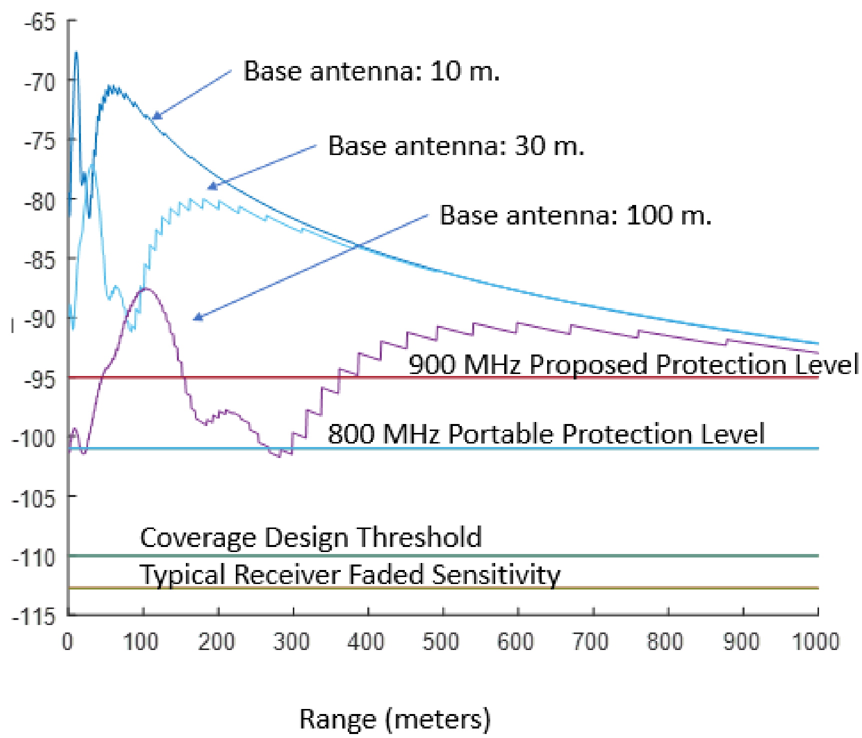

Figure 3, Receiver Sensitivity LOS Interference

include PEBB base antennas at 10, 30, and 100 meters. Deployments at 30 meters are expected to be most common, but a range was simulated to demonstrate the range of interference levels that are associated with antenna height and the directivity of the base antenna. Second, the graph is based on a

100-kHz analysis bandwidth. For the 16 LMR channels closest to the PEBB allocation, the required receiver signal may be as much as 5.3 dB higher because a 30-kHz analysis bandwidth is allowed.

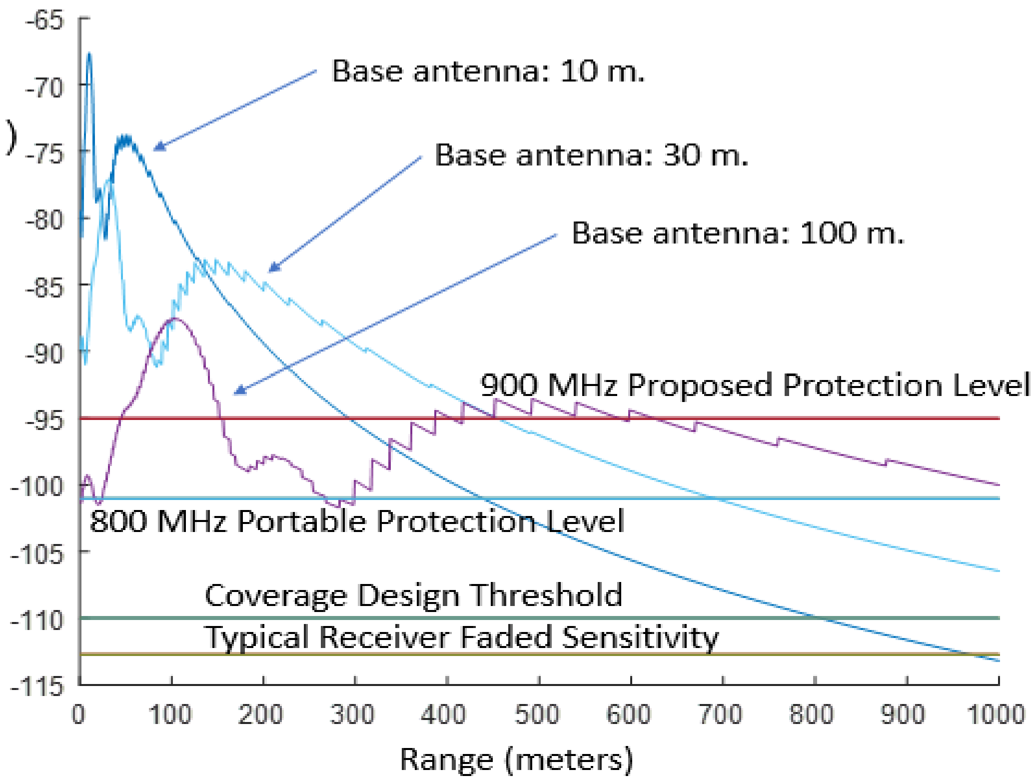

Figure 4, Receiver Sensitivity with Interference

The noise in the base station is treated as line of sight where free space is an appropriate model. This model would apply where the ground is relatively non-reflective, and obstructions do not exist in the field to act as barriers or reflectors. Based on this RF model, harmful interference above the protection level is continuous beyond 1 km from the broadband site.

To understand what receiver levels would be required in a more congested environment, a second model was generated that used free space losses to a range distance that was 3 times the antenna height. At greater range, a more typical coverage model using an exponential of 3.4 was used. Figure 4 illustrates that substantial interference can still be expected with a typical 30-meter cell tower generating interference above the 900 MHz proposed protection level out to 300 meters, 450 meters with the 800 MHz protection threshold, and 800 meters before the coverage design threshold is met.

Both line of sight and more typical terrestrial models for coverage predict a substantial amount of harmful interference associated with the proposed 50 + 10log(P) emission mask. Based on this evidence of significant and harmful interference from LTE base stations, one can look to existing regulations and standards to provide guidance in similar band configurations. Specifically, do Commission rules or standards have existing rules designed to address frequency adjacency of LTE and LMR technologies?

Both the FCC and 3GPP adopted rules for the 700 MHz band specifically designed to protect LMR signals from adjacent LTE base station out of band emissions. The applicable commission rule can be found in 47 CFR §90. 543(e) and is included here in its entirety.

> *(e) For operations in the 758-768 MHz and the 788-798 MHz bands, the power of any emission outside the licensee's frequency band(s) of operation shall be attenuated below the transmitter power (P) within the licensed band(s) of operation, measured in watts, in accordance with the following:*
>
> *(1) On all frequencies between 769-775 MHz and 799-805 MHz, by a factor not less than 76 + 10 log (P) dB in a 6.25 kHz band segment, for base and fixed stations.*
>
> *(2) On all frequencies between 769-775 MHz and 799-805 MHz, by a factor not less than 65 + 10 log (P) dB in a 6.25 kHz band segment, for mobile and portable stations.*
>
> *(3) On any frequency between 775-788 MHz, above 805 MHz, and below 758 MHz, by at least 43 + 10 log (P) dB.*
>
> *(4) Compliance with the provisions of paragraphs (e)(1) and (2) of this section is based on the use of measurement instrumentation such that the reading taken with any resolution bandwidth setting should be adjusted to indicate spectral energy in a 6.25 kHz segment.*
>
> *(5) Compliance with the provisions of paragraph (e)(3) of this section is based on the use of measurement instrumentation employing a resolution bandwidth of 100 kHz or greater. However, in the 100 kHz bands immediately outside and adjacent to the frequency block, a resolution bandwidth of 30 kHz may be employed.*

This rule is specifically designed to protect the 700 MHz LMR band from out of band emissions from LTE base stations that are in adjacent frequency allocations. It specifies that base and fixed stations must meet an OOBE mask of 76 + 10log(P) as measured in 6.25 kHz bandwidth in the 700 MHz LMR band. It further specifies that mobile and portable stations must meet a relaxed specification of 65 + 10log(P). Outside of the 700 MHz LMR protection band, the out of band emissions may follow a 43 + 10log(P) requirement.

3GPP adopts a similar rule in 36.104, that specifies emission limitations specifically for Bands 13 and 14.

The following requirement shall be applied to BS operating in Bands 13 and 14 to ensure that appropriate interference protection is provided to 700 MHz public safety operations. This requirement is also applicable at the frequency range from 10 MHz below the lowest frequency of the BS downlink operating band up to 10 MHz above the highest frequency of the BS downlink operating band.

The power of any spurious emission shall not exceed:

Table 6.6.4.3.1-3: BS Spurious emissions limits for protection of 700 MHz public safety operations

Operating Band	Frequency range	Maximum Level	Measurement Bandwidth	Note
13	763 - 775 MHz	-46 dBm	6.25 kHz	
13	793 - 805 MHz	-46 dBm	6.25 kHz	
14	769 - 775 MHz	-46 dBm	6.25 kHz	
14	799 - 805 MHz	-46 dBm	6.25 kHz	

The text is included here for convenience.

Importantly, the 3GPP and FCC rules specify equivalent emission mask levels for the base station transmitter, but specified in the typical language of the applicable document. No matter what the transmitter power 76 + 10log(P) is equivalent to an absolute level of -46 dBm/ 6.25 kHz.

The 3GPP requirement further specifies that the -46 dBm maximum emission zones applies within 10 MHz of the allocated band for the base station downlink. This additional provision ensures that adjacent bands are also protected. Specifically, if one applies this rule at 900 MHz, it ensures that adjacent bands like Sensus are protected.

Figure 5 illustrates the simulated interference levels close to an LTE base station with the standards that have been accepted by both the FCC and 3GPP to protect the 700 MHz LMR band. With this adopted standard from the 700 MHz band, the typical 30-meter cell tower only exceeds protection threshold at much closer distances to the LTE site.

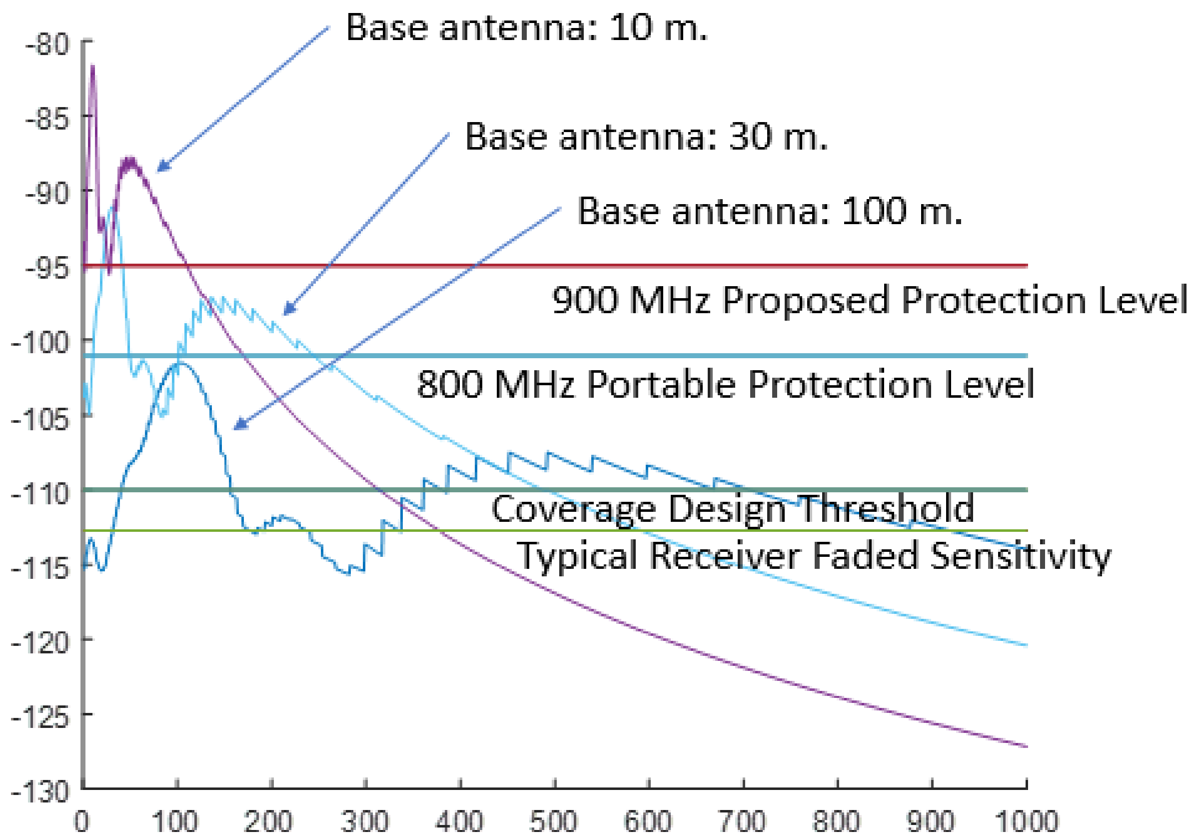

Figure 5, Existing emission mask requirement adopted from 700 MHz

Based on the simulation results and existing rules accepted by both the FCC and 3GPP, Harris recommends that emission mask requirements for the LMR portion of the 900 MHz band should follow the same rule and require 76 + 10log(P) per 6.25 kHz. The recommended 50 + 10log(P) can be applied to other parts of the spectrum external to the 900 MHz LMR allocation.

FCC rules and 3GPP standards also protect the 700 MHz LMR base station receiver from harmful interference. Harmful interference on the downlink affects LMR devices that are within RF proximity, but allows devices sufficiently distant from the LTE base station to function normally. However, a single LTE device that generates harmful interference to an LMR site can block all uplink reception for all LMR carriers at the site. Therefore, protection of the LMR base station receiver should also be ensured by an appropriate emission mask. 47 CFR §90. 543(e) and 36.101 6.6.3.2 provide emission mask rules previously agreed to by both the Commission and 3GPP as necessary to protect LMR 700 MHz operations. The similarity of the bands makes these rules applicable to 900 MHz. Both rules express the same emission mask of 65 + 10log(P) or equivalently -35 dBm as measured in a 6.25 kHz.

2. Transmitter carrier spacing

LMR systems such as the FPL system are designed to provide mission critical communication reliably, while providing the most efficient RF coverage. This means that site locations and effective radiated power are carefully designed to provide mission critical coverage reliability while maximizing the coverage of sites and minimizing coverage overlap between sites. The broadband petition calls for LMR channels to be selected from a 400-kHz allocation at the top of the band and a 1.6 MHz allocation at the bottom of the band. Like many LMR systems, the FPL system minimizes transmitter combiner losses as part of an overall strategy to maximize coverage efficiency. Minimum carrier spacing and a maximum of 3 carriers maintains combining losses below 2.8 dB. When a larger number of carriers exist at a site, multiple transmitter antennas are deployed to prevent additional transmitter losses.

The petition, by reducing the total number of channels available from 399 to 148, makes frequency planning far more difficult. Frequency planning currently must consider multiple factors including: co-channel re-use, adjacent channel re-use, existing channel licenses, and combiner spacing requirements. In a re-aligned band, satisfying the factors associated with each constraint become much more difficult.

Maximizing the spacing amongst carriers in a triple combiner would require two carriers from the lower frequency allocation and one from the upper. With less available frequency spacing than the current 5+5 MHz band, combiner losses would increase. As currently designed, the FPL system does not allow carrier spacing closer than 500 kHz and maintains losses below 2.8 dB. Within the confines of the current band, this constraint on channel selection has proven challenging. In a reconfigured band providing fewer than half the channels, the minimum channel spacing would need to be reduced to 250 kHz to provide adequate flexibility in selecting channels as frequency spacing is only one constraint on channel selection. The tighter spacing would add 1 dB of loss to the transmitter RF path and consequently 1 dB of effective radiated power. For fixed coverage reliability, the coverage area loss is estimated to be 13%. This loss is not easily recovered because it exists near the contour of coverage. The edge of coverage is not a single curve that outlines the best server coverage of each site. It also includes areas within the coverage outline that lack coverage due to geographic shadowing, manmade obstacles, and in-building signal penetration.

3. Guard Bands Play a Crucial Role in Separating Dissimilar Technologies

The Petitioners' proposal for restructuring the band, while similar in scope to the reconfiguration of the 800 MHz band eliminates the 1 MHz guard band and significantly puts into jeopardy existing operational 900 MHz systems, expansion of these systems[1], or any future narrowband systems.

By proposing a band reconfiguration without a guard band, the Petitioners are requesting a band structure that was considered and rejected in the 700 and 800 MHz bands. Detailed tradeoffs during the 800 MHz band rule making period, which ultimately resulted in a reconfiguration of that band, culminated with rules that included guard bands as the most effective way to utilize spectrum without high levels of harmful interference. Existing rules make clear that guard bands were necessary to

[1] It should be noted that the effective freeze on 900 MHz channels (only recently lifted) to facilitate 800 MHz restructuring has artificially lowered apparent demand for these channels.

separate disparate technologies. Presumably the Petitioners have not included guard bands in their petition because the 900 MHz band allocation is not wide enough to permit guard bands without substantially reducing the proposed broadband or narrowband segments.

A guard band increases the frequency spacing between interference limited cellular transmitters and narrowband noise limited receivers. This additional frequency spacing reduces the out of band broadband transmitter energy that is incident on the narrowband channels and then appears in the victim receiver channels as noise. Furthermore, it provides sufficient frequency spacing to allow various interference mitigation methods at the transmitter including highly selective infrastructure filters to reduce transmitter out of band energy. For a likely 3 MHz PEBB LTE deployment, the active part of the spectrum is 2.7 MHz wide, resulting in 150 kHz transition bands within the 3 MHz broadband allocation. A 1 MHz guard band provides more than seven times the transition frequency bandwidth between active LTE resource blocks and the closest spaced narrow band channel licenses. Without the guard band, state of the art filtering has very limited ability to provide additional noise reduction and, consequently, one of the most effective mechanisms for interference mitigation is not available. As a result, the residual 1.85 MHz bandwidth proposed for narrowband operations is effectively narrower because some number of the channels closest to the broadband allocation will be subject to high levels of harmful interference and thereby rendered unusable.

Guard bands are effective at lowering interference not only because transmitter out of band energy tends to fall off with frequency spacing, but also because the victim receiver's ability to reject interference increases with frequency spacing, and intermodulation components tend to fall off with frequency spacing as well. A guard band results in less probability of harmful interference from intermodulation components. The greater frequency spacing also ensures that those intermodulation components that do occur are typically at reduced levels.

The Commission has previously recognized[2] that operation immediately adjacent to noise limited systems in the 800 MHz band would result in high noise levels. In its rules, it specifically allowed for 800 MHz band licensees to apply for licenses within the guard band, but provided far less interference protection. In raising the protection threshold levels, the Commission recognized that it would be impractical to control interference within the guard band for narrowband noise limited systems.

If the guard band protection level provided for the guard band in the 800 MHz band was applied at 900 MHz, then protection levels would require received signal levels above -70 dBm for much of the 1.85 MHz proposed narrowband allocation. Specifically, the upper LMR band segment and more than 400 kHz of the lower LMR band segment portion would be thus affected. At the time, the Commission recognized that a lower protection level would not be practical within the guard band due to technology limitations.

The Petitioners have not demonstrated that spectral containment of broadband base station transmitters and/ or auxiliary filtering has improved sufficiently since 2008[3], to reduce out of band energy to acceptable levels that would ensure that LMR operators could expect to operate without having continuous harmful interference from broadband base station out of band energy.

Additionally, out of band energy is not the only interference mechanism. While out of band energy is typically the dominant harmful interference mechanism, if it is reduced sufficiently, then receiver performance in rejecting intermodulation and broadband energy increasingly dominate.

Narrowband mobile and portable receivers designed to operate in the 900 MHz band are designed to blocking and intermodulation performance specifications that exceed industry recommendations for the

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[2] Improving Public Safety Communications in the 800 MHz Band, *Report and Order, Fifth Report and Order, Fourth Memorandum Opinion and Order, and Order*, FCC 04-168, 19 FCC Rcd 14969 (2004), Paragraph 158.
[3] The time frame for development of the 800 MHz rules.

various protocols that operate in the 900 MHz range. These performance levels generally also far exceed requirements proposed by the Petitioners in 47 CFR §90.1427 (b). Despite the performance of these 900 MHz radios, harmful interference is anticipated to occur and be particularly pervasive due to the lack of a guard band.

By example, receiver preselection filters have been narrowed for 800 MHz LMR receivers, after 800 MHz band restructuring, to remove broadband energy produced by transmitters in the upper 800 MHz bands. These filters prevent broadband energy from overloading the narrow band receiver processing and thereby eliminate significant harmful interference that can occur with wider preselection filters when broadband operations are active in the upper 800 MHz band. Importantly, interference with wider preselection filters occurred despite receiver performance that significantly exceeded relevant industry standards.

Unfortunately, narrowing the preselector in the 900 MHz band is not nearly as practical. The 800 MHz band includes a 1 MHz guard band, a 1 MHz reserve band, and an interfering LTE broadband signal whose lower edge was spaced away from the band edge by at least 9 MHz. This effective guard spacing provided ~10 MHz for filter transitions that allow reasonable form factor filters to reject the broadband energy. The proposed 900 MHz narrowband allocation is bifurcated into two segments that surround the LTE broadband signal, effectively maximizing interference of all types. Significant rejection of the broadband allocation by preselection at 900 MHz within reasonable form factors is currently impractical. Furthermore, any technology that might provide additional resistance to these interference factors would require replacement of the entire 900 MHz fleet of existing narrowband radios.

Several operators of 900 MHz narrowband communication systems have described in detail the lack of sufficient channel licenses with comparable capabilities based on their current systems requirements and even greater challenges with meeting the need for anticipated growth. These issues were further exacerbated by the licensing freeze instituted to facilitate 800 MHz reconfiguration that has only recently been lifted.

III. LICENSE RELOCATION AND NEGOTIATION SHOULD USE EXISTING RULES

The process for license relocation and negotiation should maximize its use of existing rules particularly those written for the 800 MHz band reconfiguration. 47 C.F.R. §90.676 defines an independent transition administrator whose duties include at least: reconfiguration cost estimates, dispute mediation on cost estimates, issuing draw certificates, establishing a reconfiguration schedule, monitoring the reconfiguration, reporting progress, and dispute resolution. In contrast, the proposed rules cede authority to the PEBB license holder in a MSA or county and simultaneously reduce the power of existing license holders that plan to continue narrowband operations. In particular, administration of the realignment process is given directly to the appointed PEBB license holder for it to act at its own discretion. The proposed rules focus on clearing the broadband allocation, but pay little attention toward strategic frequency planning of narrowband channel license spectrum. The remainder narrowband allocation is expected to be highly congested in geographic areas that currently have many active licenses. Simply swapping channels on a case by case basis with no consideration of intra-system and inter-system LMR constraints will result in inadequate frequency planning that will further exacerbate challenges for incumbent licensees to receive comparable facilities. In particular, comparable facilities should consider not just an individual channel swap, but the overall frequency plan that ensures LMR mission critical performance and maximizes band capacity.

The proposed rules do not provide for an independent "realignment frequency planner." More specifically, a new set of rules for band restructuring is not required for the 900 MHz band. Instead, any future restructuring should be based on existing rules already defined for the 800 MHz band.

IV. PRIOR EXPERIENCE WITH HARMFUL INTERFERENCE TO LMR SYSTEMS

Harris has extensive field experience operating LMR systems as well as understanding interference issues and methods for mitigation of harmful interference. Post re-banding of the 800 MHz LMR band, Harris encountered harmful interference between cellular signals in Band 5 and the 800 MHz LMR band. The harmful interference was reported by our customers as their field experience with lost messages, voice dropouts, and general voice quality challenges in certain locations within their service area. Careful analysis of the reported issues identified and subsequently verified that Band 5 LTE base station transmissions were causing the harmful interference that occurred within proximity to the Band 5 sites. Harris worked with the Band 5 operator and its customer to obtain interference reducing mitigations based on protections from harmful interference, obligations to mitigate, and procedures provided by 800 MHz rules in 47 CFR §90.672 – 90.674. While Harris radios were fully compliant with the Commission requirements to receive full protections and the Band 5 operator provided mitigations, Harris also realized that the protection rules, while essential, were also very cumbersome and costly to invoke. Therefore, the interests of all parties would be served by minimizing the potential for harmful interference pro-actively by improving the LMR receiver rejection capability (of out of band interference) rather than achieving mitigation of harmful interference by protection rules.

Harris engineering determined that tighter pre-selection of the 800 MHz LMR band was possible and subsequently produced radios with a tighter pre-selector for appropriate markets. The tighter pre-selector has largely eliminated this specific interference mechanism thereby reducing mitigation costs for all stakeholders.

This experience is particularly applicable to understanding appropriate technical and protection rules that should govern a 900 MHz band that permits broadband operations, as well as to understanding the challenges created by the unique 900 MHz band plan proposed. The interference issues encountered at 800 MHz could not easily be mitigated at 900 MHz. As deployed, the LMR 800 MHz band allocates channel licenses from 851 - 860 MHz for the LMR downlink. Band 5 is defined for its downlink channel from 869 – 894 MHz. Consequently, as a minimum, interference was a result of signals that were separated by more than 9 MHz. This frequency spacing provided a transition band for tighter filtering. In contrast, the proposed 900 MHz band restructuring provides for no separation between the broadband allocation and LMR channels, and the latest proposal splits the LMR allocation into two segments that surround the proposed broadband allocation, thereby bringing a higher percentage of the LMR channels closer to the proposed broadband allocation.

Filtering at the LMR receiver to address interference issues like those described in the 800 MHz band is generally not possible because no transition (guard) band exists between the source of interference and operational LMR channels.

A similar challenge occurs for harmful interference from LTE base station out of band emissions that raise the noise level in LMR receivers. A pragmatic approach to LTE base station deployments would be to consider a certain level of out of band emission performance that can be analyzed and predicted to not cause interference above the protection threshold for most base station deployments. This level was discussed in previous sections in support of requiring 76 + 10log (P) as the emission mask for the downlink in the 900 MHz band. For sites where this level of out of band emission caused harmful interference, additional filtering could lower band emissions further as required. However, the proposed band plan at 900 MHz does not provide a guard band and therefore cannot generally provide a sufficient transition band for practical filtering.

V. APPENDIX: RESPONSES TO PETITIONERS' "FURTHER COMMENTS" DATED MAY 1, 2018

A. DETAILED RESPONSES TO PETITIONERS' UPDATED DOCUMENT

The following comments detail specific responses to "FURTHER COMMENTS OF ENTERPRISE WIRELESS ALLIANCE AND PDVWIRELESS, INC.", dated 1 May 2018. Comments appear in the same order and with the same headings as in that EWA/PDV document.

PETITIONERS' <u>"EXECUTIVE SUMMARY</u>"

Responses to bulleted proposed changes in the Executive Summary beginning on page (iii) of the Petitioners' document. These comments also apply to the same bullets that reappear in Petitioners' "I. Introduction."

"…EWA/PDV recommend the following revisions to the original Private Enterprise Broadband ("PEBB") proposal:"

- <u>*"Shift the PEBB allocation down 400 kHz to 897.600-900.600/936.600-939.600. …"*</u>

  The Petitioners, in shifting the PEBB allocation lower by 400 kHz moves the broadband allocation away from Narrowband PCS systems operated by Sensus America, Inc. In providing this change, the Petitioners have implicitly admitted that significant interference may be associated with proximity to planned broadband operations as proposed. Yet, the Petitioners have not proposed changes to FCC rules to ensure less interference. In fact, the proposed emission mask "50 + 10log(P)" does not provide for any roll-off in out of band emissions as a function of frequency separation. Therefore, the allocation shift does not provide any additional protections to Sensus from the proposed rules. However, Sensus might benefit if deployed base station equipment happens to significantly exceed the proposed emission mask requirement. In relaxing the device transmission emission mask, greater interference in the uplink band is now allowed compared with the previous petition proposal. This additional allowed interference is particularly relevant because the Petitioners mention that their intention is to use standard Band Class 8 devices. As further developed in the next bullet, these "standard" devices are developed for band plans in other parts of the world that do not have the same spectrum adjacency uses. Consequently, these devices may introduce significant interference outside their broadband allocations. Like the down link emission mask rule, the uplink rule [43 + 10log(P)] offers no improvement in out of band energy as a function of frequency spacing. This means that little benefit may arise from the 400-kHz spacing. If, however, devices do have a reduction in out of band energy as a function of frequency spacing, twice as many LMR channels are damaged by this frequency proximity. Degradation may be a combination of out of band energy from LTE base stations and receiver overload that results in receiver desense from mechanisms including intermodulation and blocking.

An additional claim is made that creating upper and lower PLMR segments allows greater separation of LMR carriers. In fact, much greater separation is possible in the current 5 MHz band with 399 channels. Splitting the LMR band into segments reduces the number of available channels to 148, significantly less than the 160 expected from a 2 MHz spectrum slice. Minimizing transmitter combiner losses requires that all channels in a combiner are separated. Therefore, combining more than two carriers will limit benefits of the upper segment that is effectively only 31 channels wide. Furthermore, the upper LMR segment channels will be quickly exhausted for purposes of maximizing transmitter combiner carriers.

- *"Adopt an asymmetrical emission mask by adjusting the uplink (897.600-900.600 MHz) mask to the standard limit of 43 + 10 log (P) dB while retaining the 50 + 10 log (P) dB mask for downlink (936.600-939.600 MHz) spectrum. …"*

In adopting an asymmetrical emission mask, the Petitioners reduced the protections provided by the previously proposed emission mask, while contending that the original emission mask was designed to address prior Sensus concerns. In fact, LMR systems are sensitive to the same noise issues, and splitting the LMR allocation doubles the number of channels that may be affected by nearby LTE devices. As for the downlink, a detailed discussion of a proper emission mask requirement is provided in Section II.B.1. While the Petitioners claim that the proposed emission mask is more stringent than normal, it falls far short of the out of band emission protections required by both the FCC and by 3GPP to protect LMR operations in the 700 MHz band. This rule[4] ensures far less harmful interference to LMR devices exists in the proximity of LTE base stations and is a compromise reached during rule making for the 700 MHz LMR band to balance practical deployment of LTE while providing adequate protections of LMR operators. The 76 + 10log(P)[5] rule greatly reduces, but does not eliminate harmful interference.

An additional claim is made that standard Band Class 8 subscriber devices could be used based on the reduced emission mask requirements. As part of its standard process in adding LTE bands, 3GPP looks at each band and its potential for causing harmful interference to other bands. Band 8, as defined by 3GPP, was never intended to be deployed in the United States and more specifically anywhere as proposed. Therefore, 3GPP requirements have never considered appropriate rules for Band Class 8 operations in the United States. By way of example, 3GPP has adopted out of band emission requirements in 36.101 §6.6.3.2 that are band specific to address regional and band specific co-existence requirements. Within this section, Table 6.6.3.2-1 Requirements, enumerates specific requirements for each band and their regional applicability. One can identify within this Table rules designed to protect LMR operations in the United States

[4] 76 + 10 log(P) per 6.25 kHz

[5] The 76 + 10log(P) emission mask is applied for a 6.25 kHz analysis bandwidth closely matching P25 signals. The 50 + 10log(P) emission mask is applied over 100 and 30 kHz bandwidths that do not match narrowband signals.

from LTE operations that are frequency adjacent. Specifically, LMR 700 MHz operations from Band 13 and Band 14 cellular devices are protected by requiring a -35 dBm/ 6.25 kHz [equivalent to 65 + 10log(P)] out of band energy level. No such requirement exists in Band 8 because the proposed 900 MHz broadband operation has never been considered. However, given the similar technologies involved and similar frequency characteristics, the same rule would be necessary for practical co-existing operations.

- *“During the first year after adoption of PEBB licensing rules, allow PE/CII applicants exclusively the opportunity to secure PEBB licenses through the traditional frequency coordination process. …”*

  License awards should be predicated on the demonstrated intent to build out a broadband system and not by simply demonstrating ownership of fallow licenses combined with FCC inventory.

- *“After the one-year coordinated application period, in markets where no PE/CII entity has secured the PEBB license, conduct overlay auctions with the PEBB license awarded to the highest bidder, whether commercial or PE/CII applicant. …”*

  One year is not enough time for critical infrastructure entities and other incumbents to develop funding to purchase broadband licenses and develop committed plans for broadband system development. The auction process should require a demonstrated intent to build out a broadband system.

“INTRODUCTION”

Unlike the Petitioners’ claim that broadband can be added to the 900 MHz band without interference, we believe that the proposed rules will cause harmful interference to existing operations. Our intent is not to preclude broadband nor to ensure that no interference is created, but instead to safeguard that harmful interference is rare and that proper provisions in the Commission rules provide for mitigation when such conditions exist.

- ***The shift in PEBB allocation*** – (see comments to Executive Summary, above)
- ***Adopting an asymmetrical emission mask*** – (see comments to Executive Summary, above)
- ***During the first year after adoption of PEBB licensing rules…*** - (see comments to Executive Summary, above)
- ***After one year coordinated application period…***- (see comments to Executive Summary, above)

“RELOCATING THE PEBB LICENSE WOULD BE RESPONSIVE TO BOTH PLMR AND NPCS ISSUES, BUT ANY CHANGE MUST ALSO ACCOMMODATE AAR REQUIREMENTS”

A. As stated in Section II.B.1 of this paper, the interference from LTE base stations just meeting the proposed emission mask is far from *de minimis*. Surrounding each LTE site, LMR devices can expect to be subject to harmful interference out to a kilometer when shadowing obstructions do not interfere with line of sight propagation. LTE deployed to just meet contiguous coverage requirement requires at least 4 times as many sites. More typically, LTE is deployed with higher site densities to meet capacity demands. The proposed emission mask will turn LMR coverage into “Swiss cheese” with coverage holes surrounding each LTE site. The size of each coverage hole being dependent upon the relative signal strengths of the serving LMR site and the interfering LTE site. Some mitigation is possible with co-location of LMR and LTE sites, but this is only possible at a small fraction of LTE sites because LMR site densities are much lower.

   Co-location where possible is also challenging due to site use arrangements. LMR operator incumbents may have substantially differing models for the terms they face and for how they pay for locations to mount site antennas. By example, a utility may own a substantial number of its sites that are located at their operating facilities. A PEBB that is operating a for profit service may choose to lease its antenna mounting locations from companies offering tower and building antenna site locations. These differences in operating model tend to limit co-locations or require higher operating costs to accommodate new agreement models.

Section II.B.1 (of this paper) describes the existing precedent supported by both the FCC and 3GPP rules that provides for an asymmetric emission mask requirement of 76 + 10log(P) for the downlink and 65 +10log(P) for the uplink. The section also demonstrates the lower level of harmful interference generated by base stations compliant with this existing requirement. Even with this more stringent emission mask, interference is not eliminated, but interference zones where LMR devices will fail to provide mission critical service surrounding LTE sites are more limited.

While we do not dispute that transmit combiners exist that can operate with carrier spacing down to 150 kHz or even narrower, RF losses are higher. LMR systems are generally implemented to maximize coverage for each site and thereby minimize both the capital and operating cost of these communication systems. Consequently, transmitting equipment is commonly run at full power, and RF combiners and feedline losses are minimized. Higher combiner losses, from tighter channel spacings, result in sites that are too far apart to provide mission critical performance. Filling these gaps that exist at the coverage contour and in the handover regions between every site is very expensive.

The Petitioners assert in their Section IV §A: *"The record confirms that an immediately adjacent PEBB system would cause less potential interference to these AMI operations than would the narrow band PLMR system already authorized to operate in immediate proximity to NPCS."* This assertion is simply not true. First, "the record" is a study performed by an advocate of the

Petitioners. In this study, the erroneous presumption is made that LMR transmitters have very high levels of out of band emissions. While it is true that the FCC rule for spurious emissions is governed by 43 + 10log(P), this requirement was established decades ago when radio equipment was more subject to spurious narrow band emitters. It has never been updated. LMR base stations and devices deployed at 900 MHz meet and typically significantly exceed P25 standards for emission mask requirements or other applicable requirements that are much more stringent than the FCC emission mask. Additionally, most sites include transmitter combiners that further suppress out of band emissions by 20 – 30 dB from their base station output levels. Therefore, LMR transmissions have very low out of band emissions and, consequently, Sensus has not experienced systemic problems with LMR neighbors, nor would it be expected.

Second, in contrast to LMR signals that are very narrowband and whose out of band emissions fall off naturally with distance from the transmitter carrier, LTE signals do not inherently have this characteristic. LTE signals have high peak to RMS ratio and therefore require linear amplification. Depending on the technique and performance of the linearization techniques used to provide the transmission signal, LTE often exhibits substantial out of band energy.

Major manufacturers of LTE base stations, at least in part driven by their customers, the cellular operators, generally provide out of band emissions that significantly exceed standards and regulatory requirements. This performance requirement is driven by the carriers who understand the substantial cost of addressing interference mitigation after system deployment. However, the 900 MHz band as proposed may consist of many small operators that do not have the historical background that the major carriers have. Consequently, proper co-existence rules in this band are particularly important to ensure successful co-existence and to prevent continuous interference mitigation. Therefore, FCC rules in the 900 MHz band should address the unique nature of the proposed band plan and impose rules that provide sufficient protection of incumbent operators.

B. Association of American Railroads (AAR's) Advanced Train Control System (ATCS) Operation Must be Accommodated in the Band Plan.

While we certainly agree that AAR's needs should be accommodated in the band plan, any planned allocation would presumably come from the LMR band segment. Therefore, in understanding the proper rules required for the band an understanding of this allocation is also required. As the Petitioners' comments read, they appear to be offering a *quid pro quo* such that if AAR is willing to give up their current allocation, the Petitioners will offer adjacent channels that could be aggregated. This offer could further substantially cut into the bandwidth available for continuing LMR operations by other users (*i.e.*, utilities). Furthermore, no study has been presented of AAR signals, particularly of wide band signals (using aggregated 12.5 kHz channels) and their potential co-existence with LMR and LTE signals.

B. COMMENTS to PETITIONERS' ATTACHMENT 1, "PROPOSED RULES"

"17. Section 90.209 is proposed to be amended…"

"§90.209 Bandwidth limitations"

"(b) ***"

"(3) For all other types of emissions, except for emissions associated with PEBB systems under subpart AA of this part, the maximum authorized bandwidth shall not be more than that normally authorized for voice operations."

The exception for PEBB systems should also include AAR requirements for aggregated channels and current rules that permit limited aggregation of 900 MHz channels.

“19. Section 90.213 is proposed to be amended…”

The Petitioners are asking for an exception to the frequency stability rules that are a standard provision of Part 90 bands and many other band allocations by the FCC. No reason is given for this exception. These rules serve to ensure signals remain centered in their authorized bandwidth. In requesting this waiver, the Petitioners implicitly imply some undefined advantage to its operations. Presumably, their carrier would not be required to be centered in the band, and higher levels of interference than otherwise presumed could arise. Therefore, we recommend that this waiver not be allowed without sufficient explanation and follow on analysis of its effects.

“21. Section 90.613 Frequencies available.”

…

“(2) Special provision for channels pursuant to 90.1417 of this part.”

This proposed change precludes new applications for narrowband systems that would make use of channels or modify the channel licenses within the broadband allocation. The effective date of this rule as proposed would be from the effective date of a future report and order authorizing PEBB systems. Since the date of report and orders is not normally preannounced, this date would not allow existing LMR operators to plan properly. Therefore, the effective date should be part of the report and order and postdate it.

Furthermore, the date should also consider that some MSA’s and counties may not have PEBB license holders or any horizon for deployment of a broadband system. Therefore, continued narrowband operations in the full 900 MHz band should not be obstructed by an unfunded mandate that precludes changes to narrowband channel licenses while not providing the promised funding from the PEBB to pay for these changes. This consideration is particularly important where many of the proposed PEBB licensable areas (>700) may not ever have a PEBB.

“22. Section 90.617 is proposed to be amended by modifying paragraphs (c) and (f) as follows:”

…

“(c) (1)” No new table captures the new frequency plan.

“(2)” Special provision for channels pursuant to 90.1417 of this part.

Same comment as 21. (2)

“(f) (1)” No new table captures the new frequency plan.

“(2) Special provision for channels pursuant to 90.1417 of this part.”

Same comment as 21. (2)

“23. Section 90.619 is proposed to be amended by adding new paragraphs (b)(5) and (d)(7) as follows:”

*“(b) ***”*

“(5)” Same comment as 21. (2)

****

*“(d) ***”*

“(7)” Same comment as 21. (2)

“24. Part 90 is amended by adding a new subpart AA as follows:”

The new subpart is not necessary to define regulations governing licensing and use of private enterprise broadband service. In fact, rules governing the proposed broadband allocation in the 900 MHz band should leverage existing rules.

“Proposed 90.1405 Licensing of the PEBB Spectrum”

The recommended rules in this section should carry an obligation for a PEBB licensee to deploy a broadband service, sell it, or forfeit said license. As written, an applicant for a PEBB license may simply demonstrate existing ownership of sufficient narrowband licenses along with the FCC pool to obtain a PEBB license. Since the narrowband channels are existing assets, no current investment is required to obtain such a license. Therefore, an entity with sufficient channel assets may choose to obtain PEBB licenses as a saleable asset with no intention to construct broadband services. This approach may not be a problem, if, the entity aggressively sells these assets at fair market value to other entities that intend to build-out broadband services. The Commission should consider proper governance in this matter that ensures that PEBB licenses become active broadband systems. These obligations by PEBB license holders may be included in License Term, License Renewal, and Filing requirements sections. Finally, the proposed rules include in (e)(2) provisions requiring notification of discontinued services by a PEBB, but no obligation to ever initiate or run such a service.

With over 700 broadband licensable areas, many areas may not have a PEBB applicant, but could have active LMR systems. These systems should be allowed to continue operations with unencumbered licenses until such time as a PEBB applicant is awarded a license and can fund the cost of restructuring the band.

“Proposed §90.1407 The realignment process”

As proposed, the PEBB licensee is the only authority, which acting "*in its discretion*" handles management, administration, and oversight of the process. The process does not provide for an independent entity that can balance the needs of all parties. A PEBB is naturally focused on clearing its broadband allocation, while LMR incumbents are concerned about achieving comparable facilities that consider both channel by channel swaps and an overall plan that ensures that LMR incumbent licensees maintain their mission critical coverage areas for their systems. Commission rules define an independent Transition Administrator in 47 CFR §90.676 that has overall responsibility for managing an orderly restructuring of the band. In addition to overseeing the management and logistics of a restructuring process, the Transition Administrator is responsible for area time phasing, negotiation, and an overall plan to ensure co-existence of narrowband and broadband systems at all phases of a potential restructuring. The Transition Administrator has overall responsibility for ensuring a successful band restructuring, while narrowband operators concern themselves with their systems.

"Proposed §90.1409 Realignment agreements between the PEBB licensee and incumbent licensees"

The realignment process should be re-updated to match existing procedures already defined for the 800 MHz band restructuring including incorporation of the independent Transition Administrator. These updates should also include longer time frames that reflect lessons learned during the 800 MHz restructuring, particularly as the 800 MHz restructuring is incomplete after a decade of work.

"Proposed 90.1411 Involuntary realignments"

The realignment process should be re-updated to match existing procedures already defined for the 800 MHz band restructuring including incorporation of the independent Transition Administrator. These updates should also include longer time frames that reflect lessons learned during the 800 MHz restructuring. Particularly as the 800 MHz restructuring is incomplete after a decade of work.

“Proposed §90.1413 Reimbursement of retuning costs; comparable facilities.”

As written, the proposed section does not fully define the scope of retuning costs. The rule should make clear that costs may include replacement or additional hardware and software upgrades as necessary to ensure comparable facilities provide comparable capabilities.

“(c)(ii) Comparable facilities”

Comparable facilities are already defined in 800 MHz rules by §90.699. There is no need to redefine this term for 900 MHz. However, due to the unprecedented band structure proposed, harmful interference may be more prevalent in the 900 MHz LMR allocation than the 800 MHz LMR allocation. Therefore, careful analysis needs to be made to ensure that incumbent licensees receive comparable facilities. Channels within the remainder narrowband allocation will not all have the same coverage capability. Some channels closer to the broadband allocation may be more subject to harmful interference. Other channels may be constrained by co-channel assignments that limit the effective coverage range. Still others may not provide sufficient carrier spacing to ensure transmitter losses are minimized. Incumbent licensees should be assured that their comparable facilities can achieve the same system coverage foot print with matching reliability. In some cases, comparable capacity and comparable coverage may require an increase in channel licenses for incumbent operations.

“Proposed §90.1417 Frequencies”

As previously discussed, shifting the broadband allocation lower by 400 kHz did not actually change the OOBE limit and thus provide any assurance of lower interference for Sensus. As a practical matter, if interference to Sensus is lowered by this frequency shift, then the LMR allocation must contend with twice as many channels that are affected by interference. Therefore, this change can be viewed as placating the concerns of one vendor, while damaging the communication capabilities of an industry.

"Proposed 90.1419 Effective radiated power limits for PEBB systems."

"(b) Power flux density"

The effective radiated power limits proposed are based on similar limitations in public safety Band 14. However, characteristics unique to the 900 MHz band require a more considered look at power flux density limitations. The power flux density limitations proposed are based on cellular bands that are part of communication systems that benefit from alternate bands that help to maintain communications where a high interference environment may exist in an operating band. By example, a typical commercial cell phone that encounters harmful interference in a band will handover to an alternate band that is likely not to have the same interference issue. LMR bands at 700 MHz in many cases do not have an alternate band for operations, but do benefit from a guard band that may lower out of band emission requirements discussed in detail in this paper (see comments associated with the proposed rule 90.1425 Emission Limits.)

In the 900 MHz band, LMR operators are not expected to have an alternate band to use if interference is encountered. In other bands including bands at 700 and 800 MHz, guard bands protect receivers by providing frequency separation that tends to lower out of band emissions from transmitters and reduce receiver susceptibility to blocking and intermodulation. The 900 MHz broadband allocation, as proposed, does not include a guard band and, as most recently proposed, splits the LMR allocation into two segments. Consequently, LMR receivers are more susceptible to high flux densities near PEBB base stations. Furthermore, splitting the LMR segment means that even more LMR channels are affected by frequency proximity of LTE base stations. The emission mask as proposed in §90.1425 allows a narrower analysis band of 30 kHz rather than 100 kHz to be applied for the first eight 12.5 kHz channels on either side of the broadband allocation. This allows out of band energy to be as much as 5 dB higher for 16 of the remainder LMR channels in a re-structured band.

"(b) Power flux density (PFD)"

Modern coverage analysis tools can easily model the flux density surrounding sites to ensure that flux densities are maintained below threshold levels. Therefore, flux density analysis should be performed for all LTE sites and not simply for sites that exceed a threshold ERP or have very high antenna placements. The unique proposed band plan for 900 MHz, that allows noise limited and interference limited systems to operate in adjacent allocations without a guard band greatly increase the amount of harmful interference that may occur particularly to narrowband systems.

FCC rules play an important role in ensuring that spectrum can be effectively shared by multiple users whether they share a common band or different bands. The flux density limit as proposed can be compared against §90.1425 Interference Protection Rights to understand if practical inconsistencies exists between the proposed Commission rules.

As proposed, the flux density limit for the proximity of a broadband site is 3 mW/m^2. Presuming that the victim LMR receiver is using an isotropic antenna, it will intercept a -16 dBm broadband signal from an incident broadband signal at the flux density threshold. From this intercepted level, we can then predict the required transmitter emission mask and receiver blocking and intermodulation performance required for LMR reception.

The implied out of band emission requirement must allow the receiver to successfully decode voice signals. Per the proposed protection level of -98 dBm for a mobile radio and a receiver required signal to noise and interference ratio as specified of 17 dB, the interference from out of band energy can be calculated to be -98 dBm -17 dB SINR (signal to interference and noise ratio) = -115 dBm[6] (interference). Therefore, the out of band energy required to just meet the protection threshold recommended is -16 dBm (receiver interference level from carrier) - - 115 dBm (out of band emission interference) = 99 dB below the carrier power. The proposed emission mask of 50 + 10log(P) with a 40-watt typical LTE transmitter would only provide 78 dBc suppression of out of band energy in an effective LMR bandwidth of 6.25 kHz. Consequently, an LMR receiver attempting to operate in an environment at the flux density threshold would have an effective sensitivity of -77 dBm due to out of band energy from the local broadband site. From a desense perspective the receiver is desensed by 35 dB from its typical sensitivity and desensed 21 dB from the protection level of -98 dBm. This large desense suggests all broadband sites that operate with flux densities even approaching the flux density limit could easily be shown to cause harmful interference exceeding the protection limits and therefore qualifying for abatement from this interference. The Commission rules should be written to prevent this condition and ensure that interference protections need only be invoked by exception rather than constantly.

As more fully described in our comments on proposed §90.1425 (below), we are recommending an alternative emission mask for the broadband downlink to protect the LMR portion of the 900 MHz band of 76 + 10log(P) in a 6.25 kHz channel. This emission mask is required by the FCC and required by 3GPP for co-existence of LTE Band 13 and Band 14 base station transmitters for protection of the 700 MHz LMR band. If this emission mask is applied to the prior analysis of harmful interference, then out of band emission from a LTE base station would be suppressed by 76 +16 = 92 dBc. We see, even in this case, that signal levels at the flux density threshold will result in interference that is

[6] The receiver noise floor is negligible.

7 dB above the flux density threshold. We can therefore conclude that any LTE site with flux densities approaching or even significantly less than 3 mW/m^2 can be easily shown to fail the protection threshold. In reaching this conclusion, a distinction must be made between the flux density rule and the protection threshold. While the flux density rule allows that 2% of the area within 1 km of the site may be above threshold, the protection rule has no such area requirement. Even though protection levels can be exceeded with the improved emission mask, the levels are much more manageable from a practical perspective and should result in significantly fewer claims for interference mitigation.

Returning to the flux density rule, we can also demonstrate that typical sites may exceed the allowed flux density. Significant attenuation of the antenna pattern in the immediate vicinity of the site is required to maintain flux density compliance. If an isotropic radiator is used and the ERP of the LTE site is 1200 watts for the expected 3 MHz LTE signal, then the flux density threshold is exceeded to 178 m from the antenna. For a rural deployment at a maximum ERP of 6 kilowatts, the flux density is exceeded to a distance of 399 m. However, the flux density rule only allows 2% of the surrounding 1 km to exceed the flux density limit, which corresponds to only 141 meters from the site. Although the flux density near an LTE site is a strong function of the base station antenna directivity, this basic analysis shows that antenna directivity must be considered to ensure compliance with the flux density rule. Furthermore, a lower flux density threshold should be considered for designs to ensure that interference mitigation claims are not common.

Due to the unique nature of the band plan at 900 MHz that includes no guard band, power flux density studies with compliance to the rules should be required for all broad band sites. Furthermore, the emission mask should use the precedent established in the 700 MHz band and require 76 + 10log(P).

“§90.1421 Field Strength Limit”

The filed strength limits should also apply during the band restructuring period and when no PEBB exists. These provisions protect incumbent narrowband licensees from co-channel interference.

“§90.1423 Operation near international borders”

Commission rule §90.619 and others fully define the requirements for international border coordination and coexistence. This section appears to have simplified some of these provisions. This section should either use the existing rule or fully incorporate its applicable paragraphs.

“§90.1425 Emission limits”

As previously discussed in the paper, appropriate emission masks for the 900 MHz band that are based on precedents established by both FCC rules and 3GPP standards for protection of LMR operation in the 700 MHz band should be used in the 900 MHz band. These rules establish 76 + 10log(P) as the required emission mask for the downlink and 65 + 10 log(P) as the emission mask requirement for the uplink.

“90.1427 Interference Protection Rights”

Existing Commission rules also provide guidance for interference protection limitations. As previously established, the current Commission rules governing protection in the 800 and 900 MHz band based protections for the 900 MHz band on a temporary requirement to provide less protections. These levels were set as -85 dBm for portables and -88 dBm for mobiles to enable more flexible channel shuffling that facilitated the 800 MHz re-structuring. The Petitioners have already implicitly accepted that these levels are inappropriate by raising the protection levels to -95 dBm for portables and -98 dBm for mobiles. However, these levels are arbitrary and do not reflect existing precedent already provided by 800 MHz rules. Furthermore, the simulations provide by

Figure 3, Figure 4, and Figure 5 illustrate that substantially larger coverage holes around LTE sites can be expected by the proposed lesser protections. Therefore, rules that establish protection limitations at 800 MHz should be adopted for 900 MHz.